

Blitter Registers

BLT_ADDR_0,1,2

BLT_CLIP_s

BLT_CLIP_BR
BLT_CLIP_UL
BLT_START_XY

BLT_CLIP_DELTA_X

BLT_COLOR_0,1,V_DELT

BLT_DATA

BLT_DELTA_s

BLT_DELTA_X_0,1,2
BLT_DELTA_Y_0,1,2
BLT_DELTA_DELTA_X,Y
BLT_DELTA_X,Y_LINE

BLT_FUNC

BLT_PATTERN_32

BLT_PLANE_MASK

BLT_SIZE

BLT_TEX_ADDR_CNTL

BLT_TRANS_COLOR

63	32 31				24	0			
ADDRESS				FRAC					
63	32 31				0				
X				Y					
63	32 31				0				
X									
63	56 55	48 47	40 39	32 31	0				
8 integer									
63	62 58 57	53 52	48	32 31	0				
	5 int R	5 int G	5 int B						
63	56 55	48 47	40 39	32 31	0				
8 integer R		8 integer G	8 integer B						
63	48 47		40 39	32 31	0				
8.8 fixed-point									
63	62 61	52 51	42 41	32 31	0				
	5.5 fixed-point R	5.5 fixed-point G	5.5 fixed-point B						
63	48 47		32 31	16 15		0			
8.8 fixed-point R		8.8 fixed-point G		8.8 fixed-point B					
63	32 31				0				
DATA_HI				DATA_LO					
63	32 31				24	0			
INCREMENT				FRAC					
63	56 55	48 47	40 39	32 31	24 23	16 15	8 7	0	
					CNTL	FUNCTION	MINTERMS		
63	56 55	48 47	40 39	32 31	0				
PATTERN									
63	32 31				0				
PLANE_MASK									
63	56 55	48 47	32 31	24 23	16 15	0			
		WIDTH				HEIGHT			
63	32 31				0				
X_MASK				Y_MASK					
63	56 55	48 47	40 39	32 31	0				
8 integer		8 integer	8 integer	8 integer	8 integer	8 integer	8 integer		
63	62 58 57	53 52	48	32 31	0				
	5 int R	5 int G	5 int B	5 int R	5 int G	5 int B	5 int R	5 int G	5 int B
63	56 55	48 47	40 39	32 31	0				
8 integer R		8 integer G	8 integer B		8 integer R	8 integer G	8 integer B		

Dr. Edward L. Hepler

Commodore

1200 Wilson Drive

West Chester, Pennsylvania 19380

(610) 431-9298

hepler@commodore.com

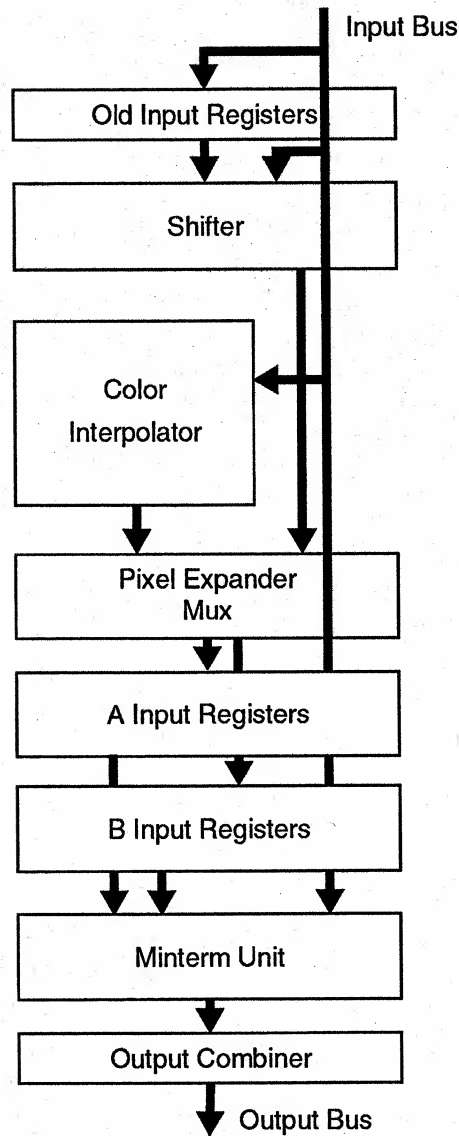


Modified: April 12, 1994
Created: October 18, 1993

Page 32 of 64

Commodore Confidential

Blitter Datapath



Dr. Edward L. Hepler

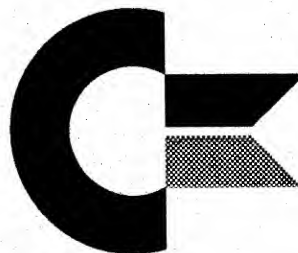
Commodore

1200 Wilson Drive

West Chester, Pennsylvania 19380

(610) 431-9298

hepler@commodore.com

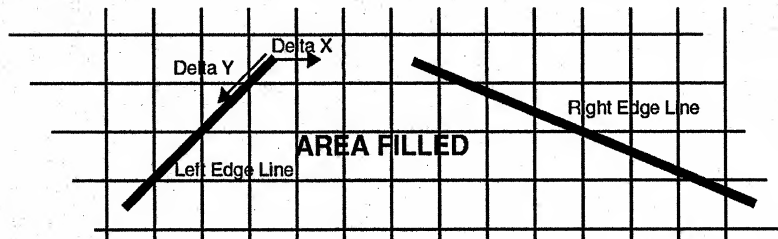


Modified: April 12, 1994
Created: October 18, 1993

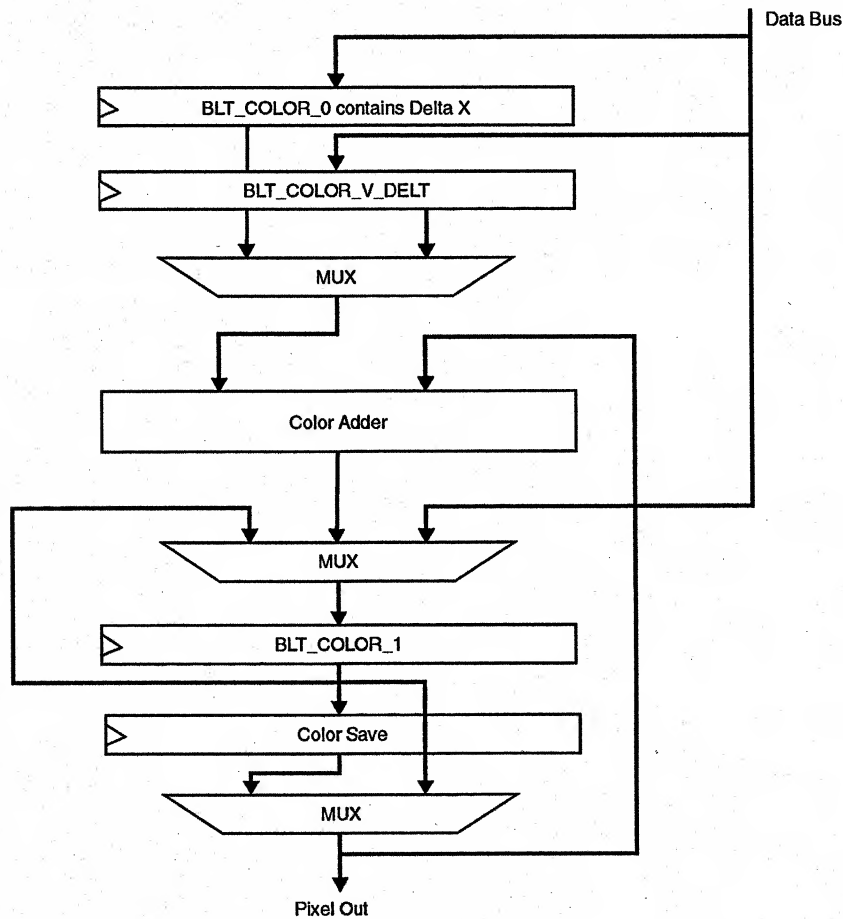
Page 33 of 64

Commodore Confidential

Blitter Assisted Shading and Texture Mapping



Color Interpolator



Dr. Edward L. Hepler

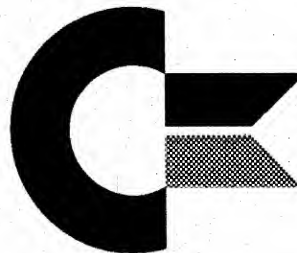
Commodore

1200 Wilson Drive

West Chester, Pennsylvania 19380

(610) 431-9298

hepler@commodore.com

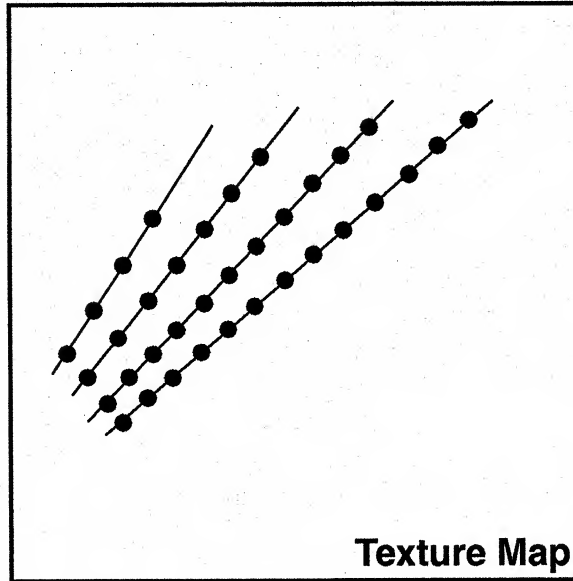
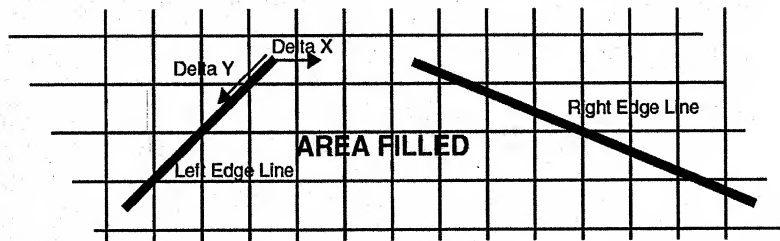


Modified: April 12, 1994
Created: October 18, 1993

Page 34 of 64

Commodore Confidential

Textured Fills



- Each pixel is individually fetched from texture map
- Texture map addressing uses fixed-point arithmetic
- Delta x,y and start position updated after each scan line

Dr. Edward L. Hepler

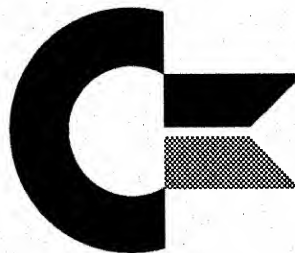
Commodore

1200 Wilson Drive

West Chester, Pennsylvania 19380

(610) 431-9298

hepler@commodore.com

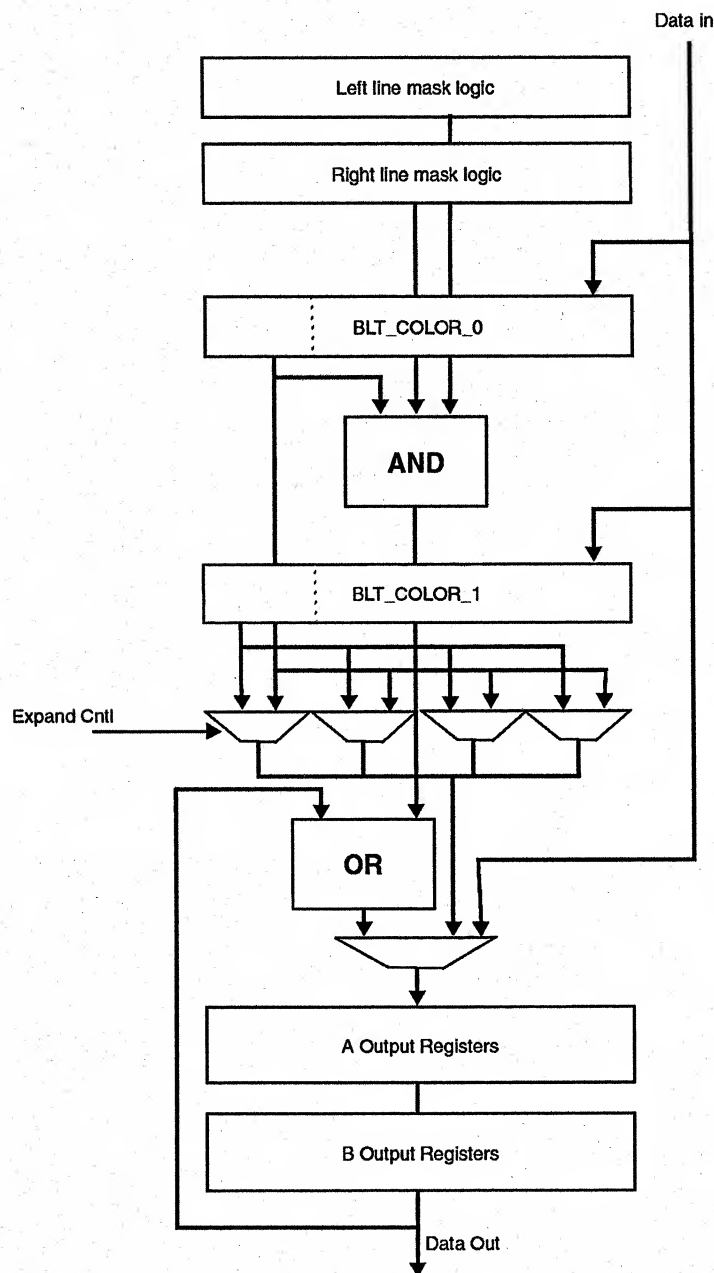


Modified: April 12, 1994
Created: October 18, 1993

Page 35 of 64

Commodore Confidential

Blitter Assisted Line Drawing and Pixel Expansion



Dr. Edward L. Hepler

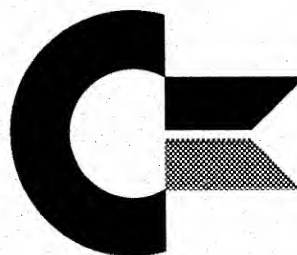
Commodore

1200 Wilson Drive

West Chester, Pennsylvania 19380

(610) 431-9298

hepler@commodore.com



Modified: April 12, 1994
Created: October 18, 1993

Page 37 of 64

Commodore Confidential

Peripheral Bus Interface (PBI)

- **Byte Interface for Hombre Chip Set**
 - Supports up to four peripheral chips (4 channels)
 - Each channel has its own register address space
 - 6 address lines (from address bits 8:3)
 - Programmed I/O from internal RISC Processor
 - DMA to/from Display memory, System memory , PCI
 - Common Interrupt line
- **Round-Robin priority scheme for DMA**
- **Programmed I/O has priority over DMA**
- **DMA must be occur to/from double-word aligned locations**
- **Configuration Register per channel:**
 - Intel / Motorola Protocol
 - Cycle length
 - Use positive wait
 - Use negative wait
 - 1 cycle wait
 - 3 cycle wait
 - DMA direction
 - Memory to peripheral
 - Peripheral to memory
 - DMA transfer size
 - 8, 16, 32 bytes
 - DMA Acknowledge Protocol
 - Normal cycle with dack
 - Transfer on dack
 - Address to chip-select delay
 - 1, 2 cycles
 - Chip-select to data-strobe delay
 - 0, 1 cycles

Dr. Edward L. Hepler

Commodore

1200 Wilson Drive

West Chester, Pennsylvania 19380

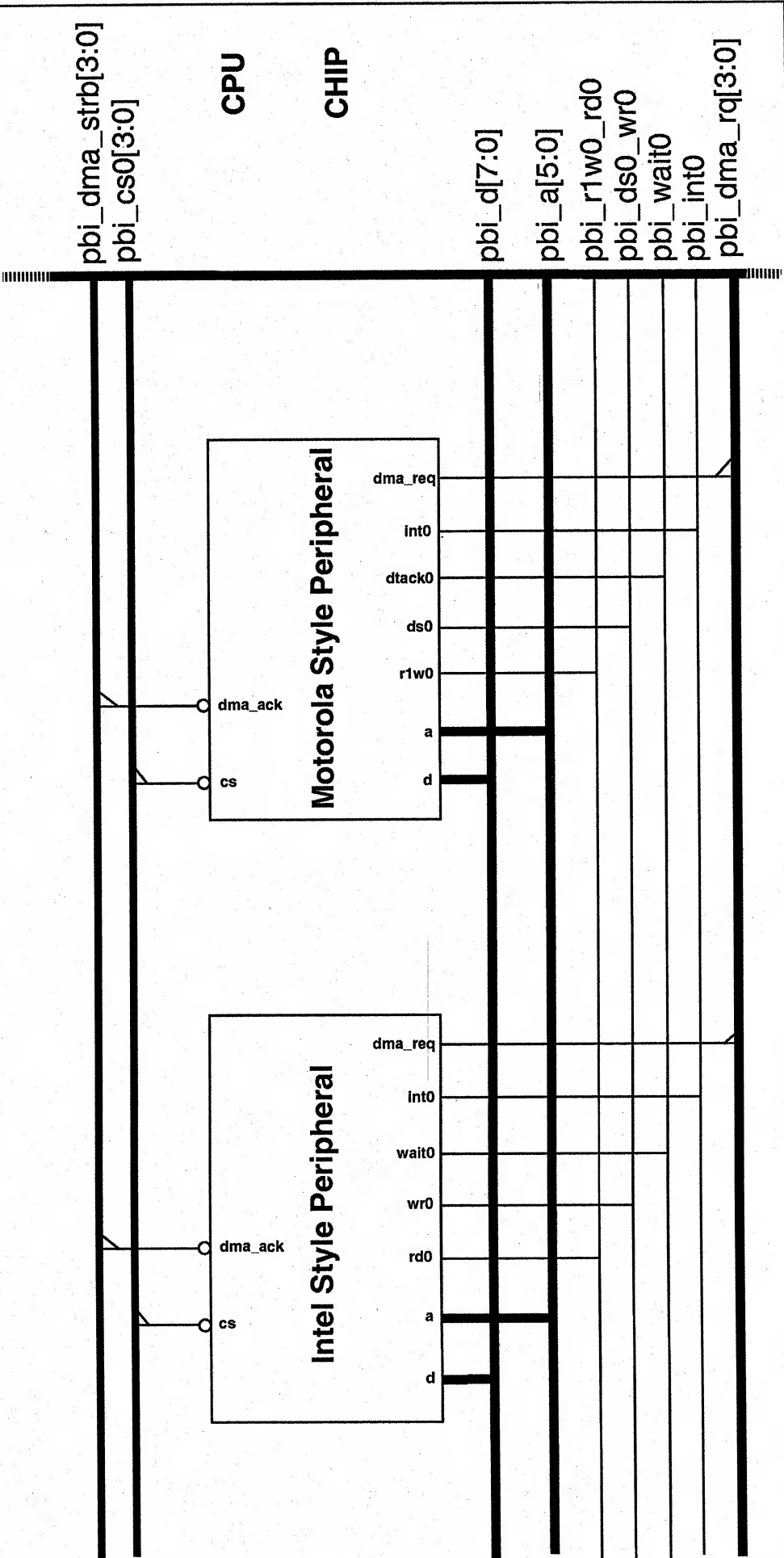
(610) 431-9298

hepler@commodore.com



Commodore Confidential

PBI Provides Glue-Free Interface to Byte Peripherals



Dr. Edward L. Hepler

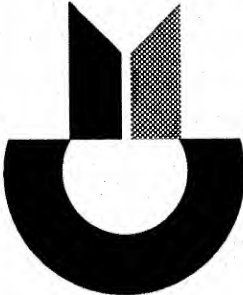
Commodore

1200 Wilson Drive

West Chester, Pennsylvania 19380

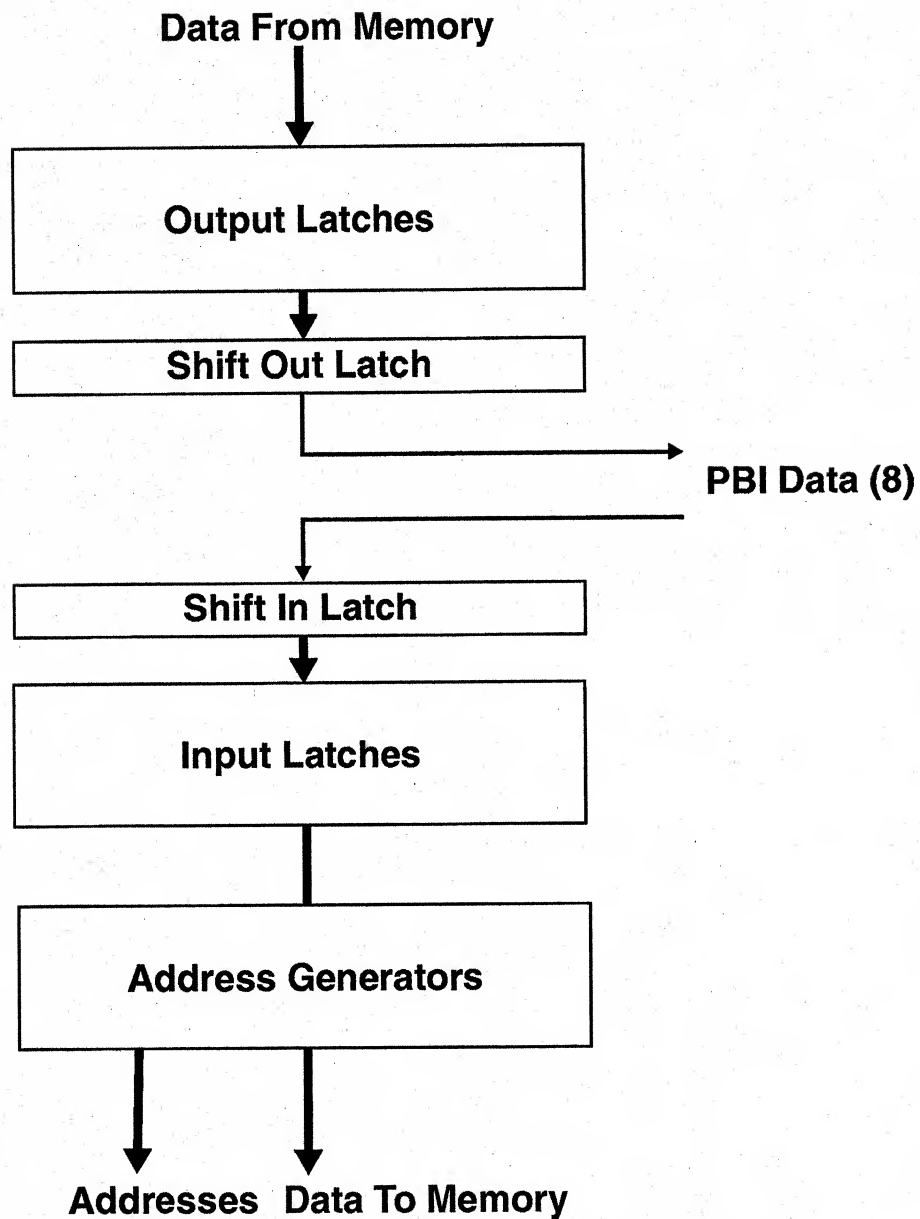
(610) 431-9298

hepler@commodore.com



Commodore Confidential

PBI Datapath



Dr. Edward L. Hepler

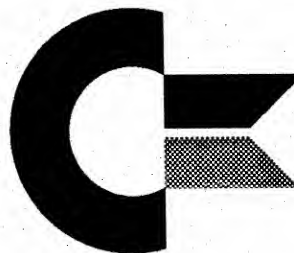
Commodore

1200 Wilson Drive

West Chester, Pennsylvania 19380

(610) 431-9298

hepler@commodore.com



Modified: April 12, 1994
Created: October 18, 1993

Page 40 of 64

Commodore Confidential

Copper

- **Video Line Synchronized “RISC” co-processor**
- **Executes lists of simple instructions including:**
 - **MOVE:** Load an HOMBRE register with a value
 - **JUMP:** Execute from a new list address
 - **WAIT:** Wait for a specified video line or relative video line
- **One level of hardware supported subroutine provided**
- **Interrupted each vertical blank event**
- **No “position enable” bits as in Amiga**
- **No horizontal matching as in Amiga**
- **JUMP instructions contain their target versus Amiga jumps which required writing a COP(1/2)(L/H) register**

Dr. Edward L. Hepler

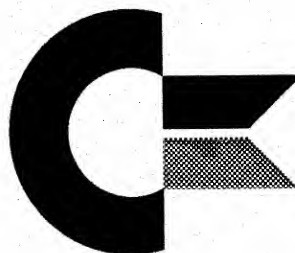
Commodore

1200 Wilson Drive

West Chester, Pennsylvania 19380

(610) 431-9298

hepler@commodore.com



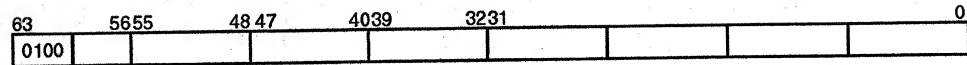
Modified: April 12, 1994
Created: October 18, 1993

Page 41 of 64

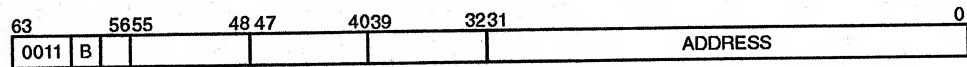
Commodore Confidential

Copper Instructions

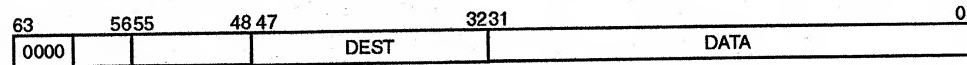
Clear ~~Relative~~



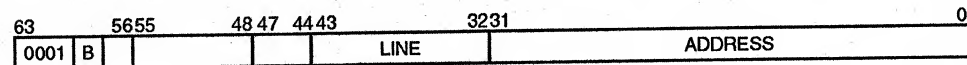
Jump



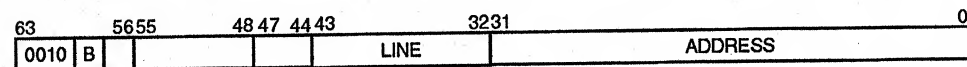
Move



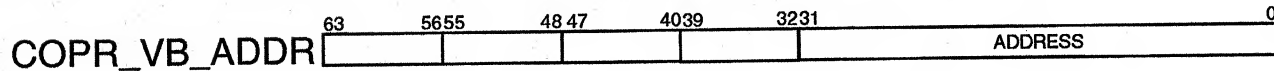
Wait



Wait Relative



Copper Register



Dr. Edward L. Hepler

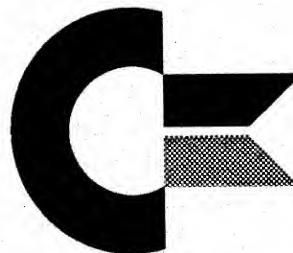
Commodore

1200 Wilson Drive

West Chester, Pennsylvania 19380

(610) 431-9298

hepler@commodore.com



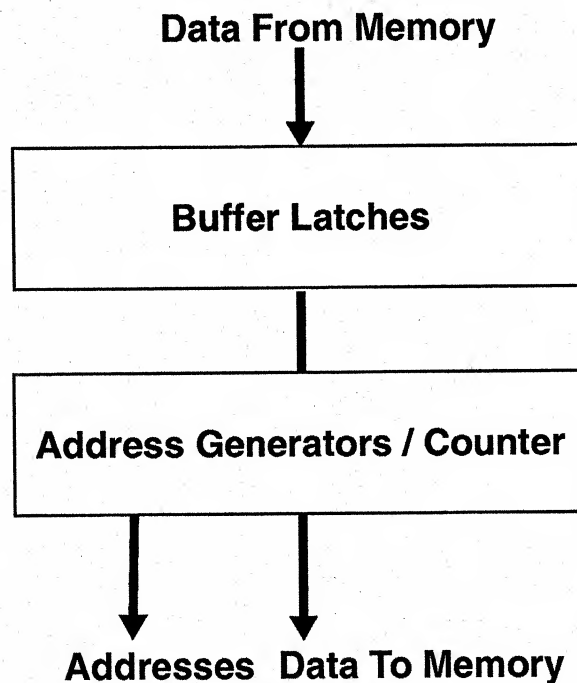
Modified: April 12, 1994
Created: October 18, 1993

Page 42 of 64

Commodore Confidential

System Copier

- **Memory to Memory Copy / Fill**
- **Copies n 64-bit doublewords from source to destination**
- **Fills n 64-bit doublewords from CPU written latch to destination**
- **Useful for data block copy, memory initialization**
- **Consider it an “Independent, Simple minded blitter channel”**
- **Utilizes burst mode memory accesses**
 - 64-bit memory: ~ 65 Mbyte/sec moves - ~ 130 Mbyte/sec fills
 - 32-bit memory: ~ 40 Mbyte/sec moves - ~ 80 Mbyte/sec fills



Dr. Edward L. Hepler

Commodore

1200 Wilson Drive

West Chester, Pennsylvania 19380

(610) 431-9298

hepler@commodore.com



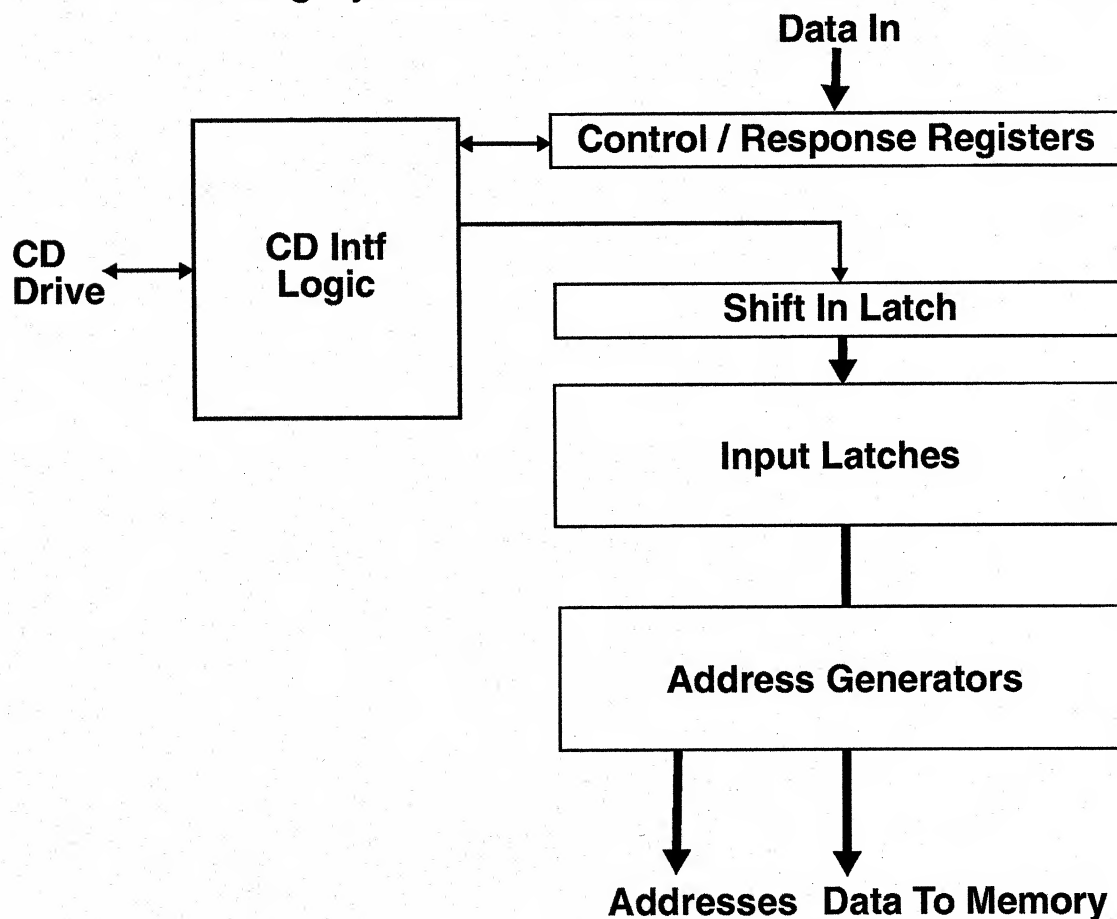
Modified: April 12, 1994
Created: October 18, 1993

Page 43 of 64

Commodore Confidential

CD-ROM Interface

- Similar functionality as in "Akiko" of CD³²
- Utilizes burst mode memory accesses
- Easily capable of 2X or greater speed.
- 3 wire data interface from drive
- Serial control/response interface to/from drive
- Data Integrity is a combination of hardware and software



Dr. Edward L. Hepler

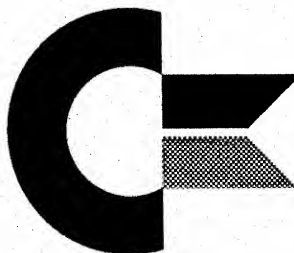
Commodore

1200 Wilson Drive

West Chester, Pennsylvania 19380

(610) 431-9298

hepler@commodore.com



Modified: April 12, 1994
Created: October 18, 1993

Page 44 of 64

Commodore Confidential

Audio

- **12 AAA style, 16-bit, 44.1 Khz, CD quality channels**
 - Will have 8-bit mode
 - ADPCM ??
- **2 CD formatted serial input lines**
 - Each has L + R... results in total of 16 source channels
 - 3 wire (Data, Bclk, Lrck) input
 - One input (L + R) can be sampled into memory
- **1 CD formatted (L + R) serial output line**
 - Intended to go to external postprocessor/amplifier
- **Postprocessor / Amplifier**
 - External
 - Provides tone / volume control for headphone line
 - Provides line-out for connection to stereo, etc.
 - Controlled via I²C Bus

Dr. Edward L. Hepler

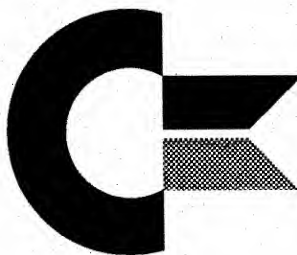
Commodore

1200 Wilson Drive

West Chester, Pennsylvania 19380

(610) 431-9298

hepler@commodore.com



Modified: April 12, 1994
Created: October 18, 1993

Page 45 of 64

Commodore Confidential

Display/System Memory Controllers

- **Configurable for 9, 10, or 11 bit multiplexed memory addresses**
- **120 ns memory cycle**
 - One word read: 120 ns
 - Four word burst: 240 ns
- **Configurable for memory organizations:**
 - 32 bit (80 Mbytes/sec - 200 Mbytes/sec graphics)
 - 64 bit (133 Mbytes/sec - 400 Mbytes/sec graphics)
- **Burst across page boundary**
- **Supports RMW cycles for individual byte writes**
- **RAS decoding for 4 banks**
- **VRAM access control**
- **CAS before RAS refresh**

Dr. Edward L. Hepler

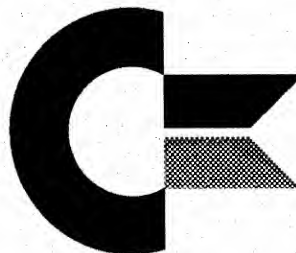
Commodore

1200 Wilson Drive

West Chester, Pennsylvania 19380

(610) 431-9298

hepler@commodore.com

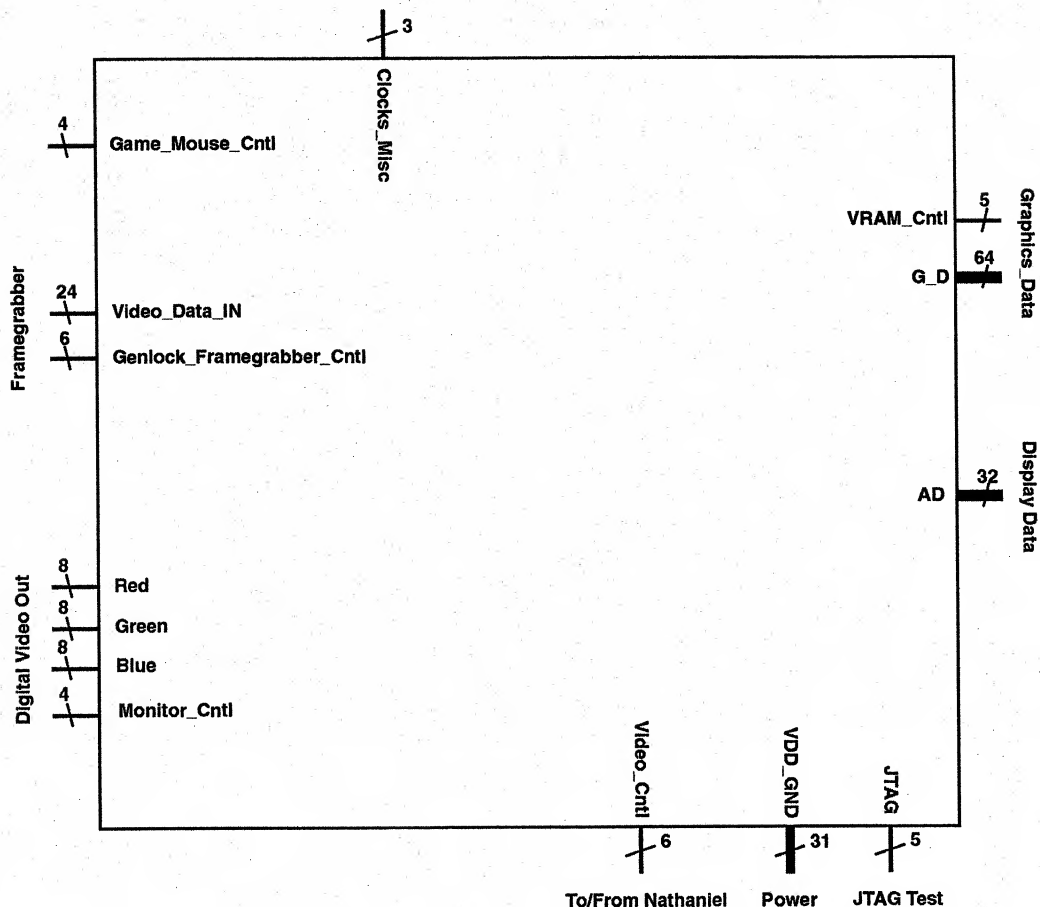


Modified: April 12, 1994
Created: October 18, 1993

Page 46 of 64

Commodore Confidential

Video Chip (Natalie)



• Functions:

- Line Buffers
- Cursor Ram
- 512 x 25 CLUT
- Framegrabber
- Genlock
- YUV -> RGB (MPEG)
- Mouse/Game Cntrlr Intf

• Interfaces:

- 32/64-bit Graphics Data (VRAM)
- 32-bit Display Memory (high 32)
- 24-bit Digital RGB out (ext D/A)
- 24-bit (option to 8+16) Video IN
- Serial Mouse - Game Control
- 177 Signals / 31 Power-Ground
- 208 PQFP (225 BGA)

Dr. Edward L. Hepler

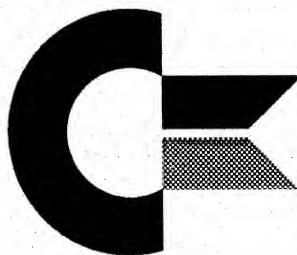
Commodore

1200 Wilson Drive

West Chester, Pennsylvania 19380

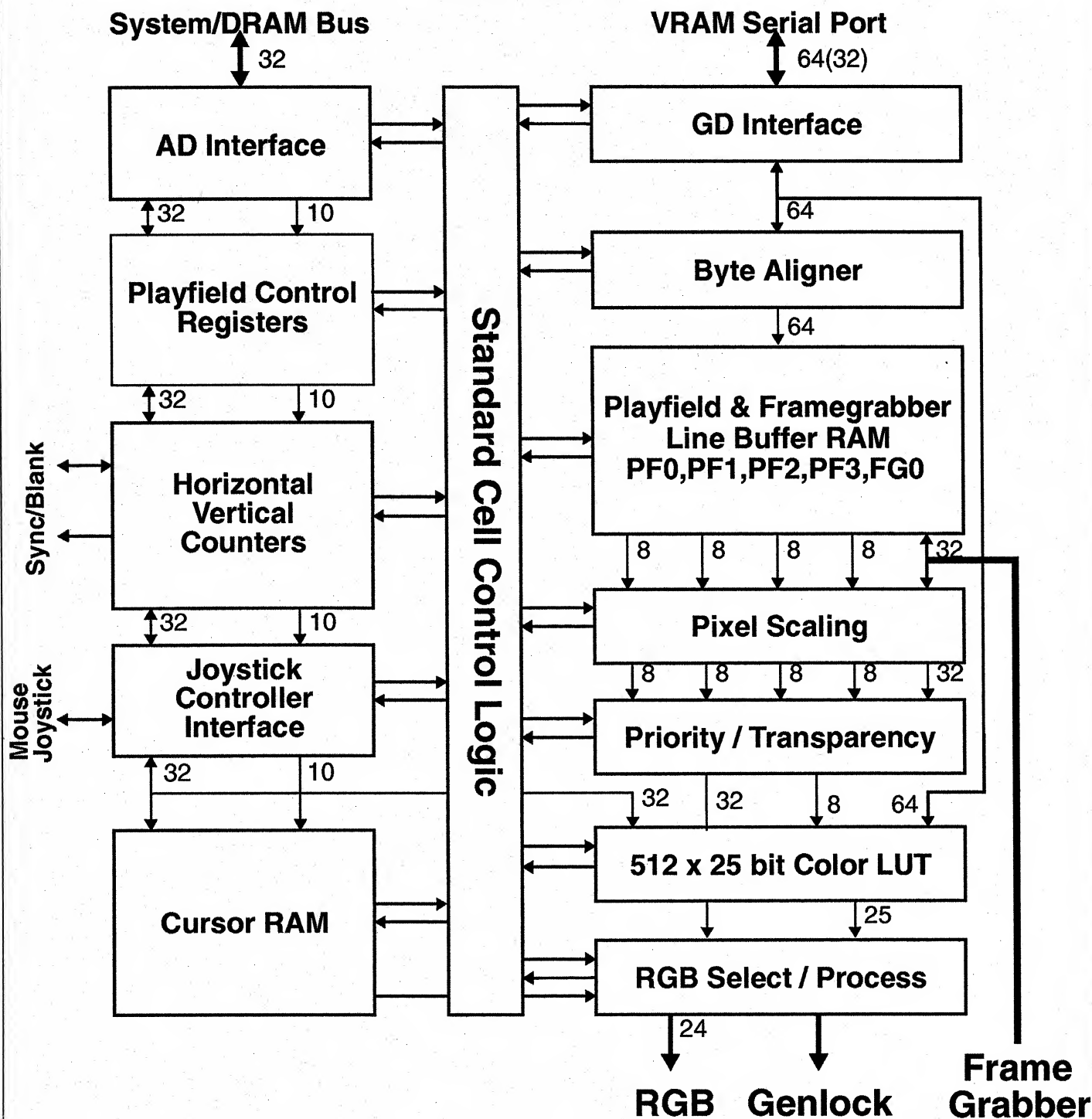
(610) 431-9298

hepler@commodore.com



Modified: April 12, 1994
Created: October 18, 1993

Functional Block Diagram of Video Chip



TMCD

Dr. Edward L. Hepler

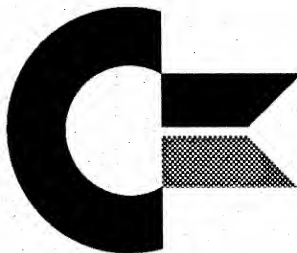
Commodore

1200 Wilson Drive

West Chester, Pennsylvania 19380

(610) 431-9298

hepler@commodore.com



Modified: April 12, 1994
Created: October 18, 1993

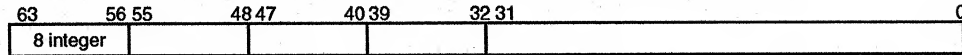
Page 48 of 64

Commodore Confidential

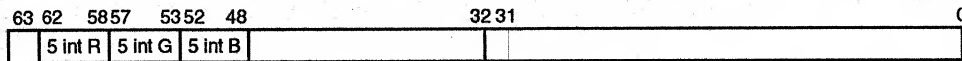
Video Modes

Pixel Formats

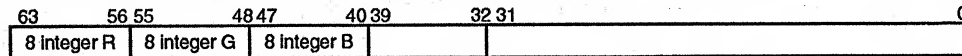
- 8-bit palette, HAM8:



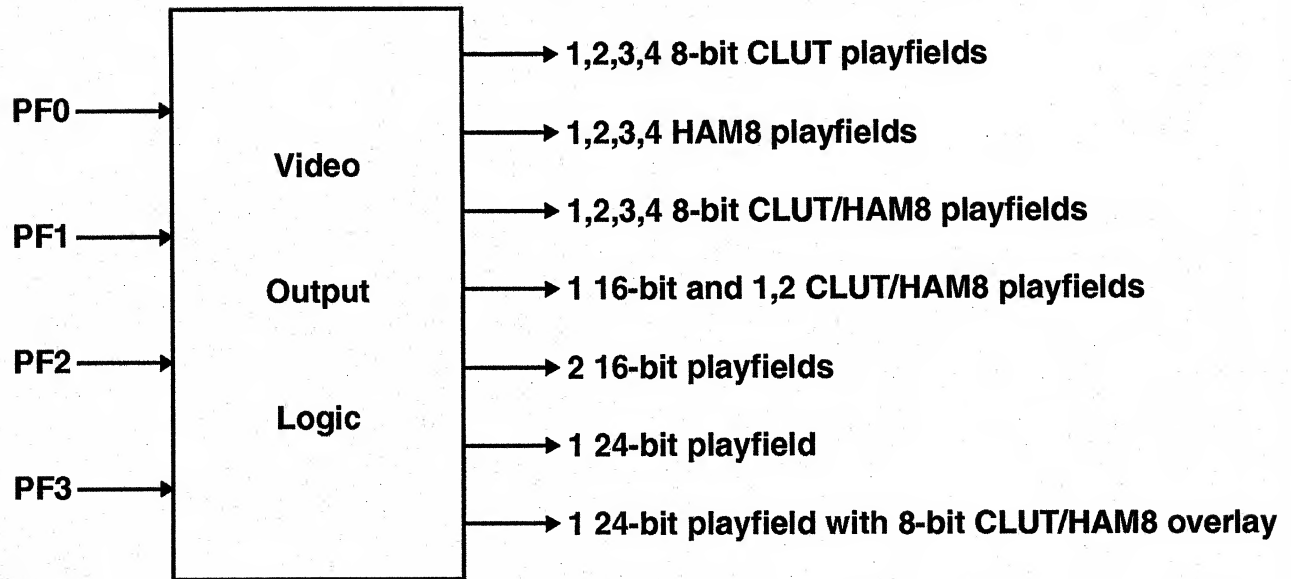
- 16-bit RGB (Hi-color):



- 24(32)-bit RGB (True-color):



Output Selection



Each playfield is individually positionable, scrollable, and scalable

Dr. Edward L. Hepler

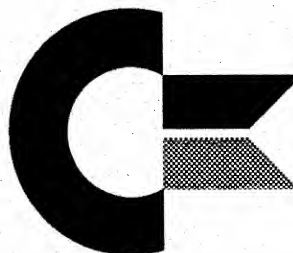
Commodore

1200 Wilson Drive

West Chester, Pennsylvania 19380

(610) 431-9298

hepler@commodore.com

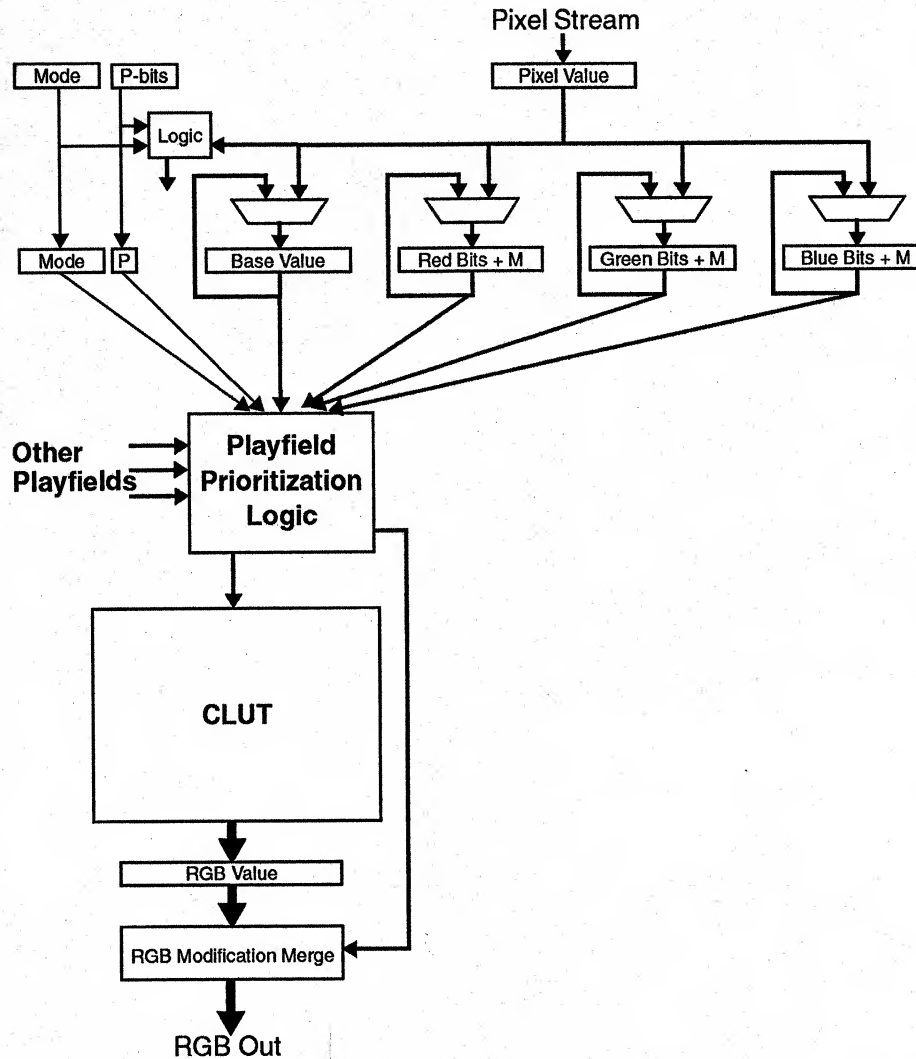


Modified: April 12, 1994
Created: October 18, 1993

Page 49 of 64

Commodore Confidential

HAM8 Video Mode Operation



Dr. Edward L. Hepler

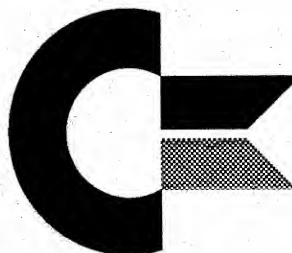
Commodore

1200 Wilson Drive

West Chester, Pennsylvania 19380

(610) 431-9298

hepler@commodore.com

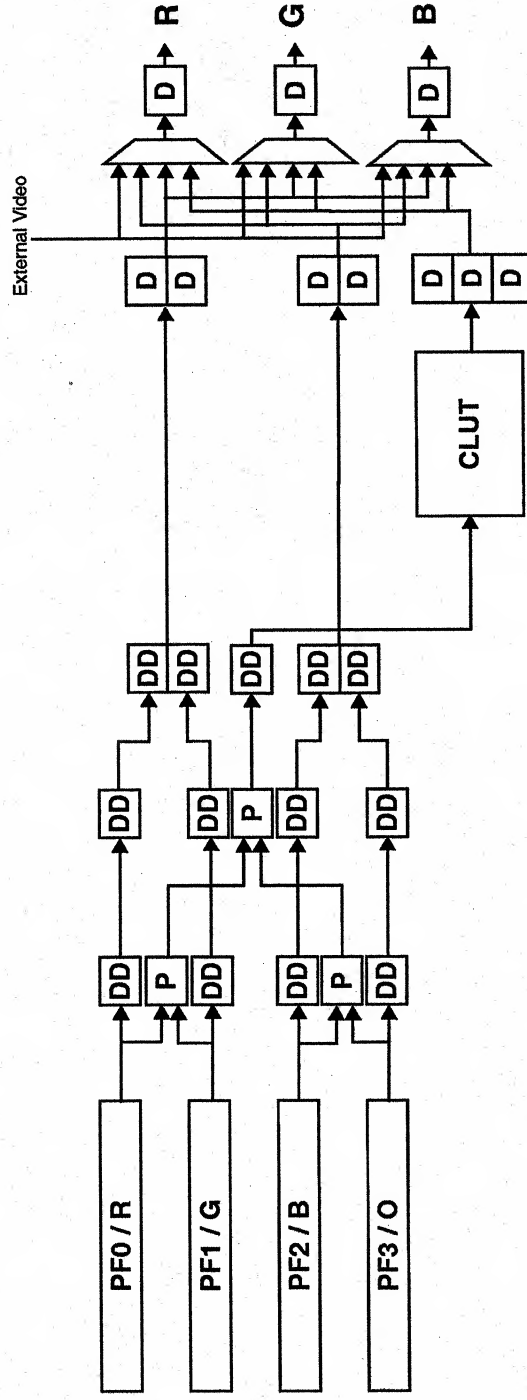


Modified: April 12, 1994
Created: October 18, 1993

Page 50 of 64

Commodore Confidential

Video Output Processing



Dr. Edward L. Hepler

Commodore

1200 Wilson Drive

West Chester, Pennsylvania 19380

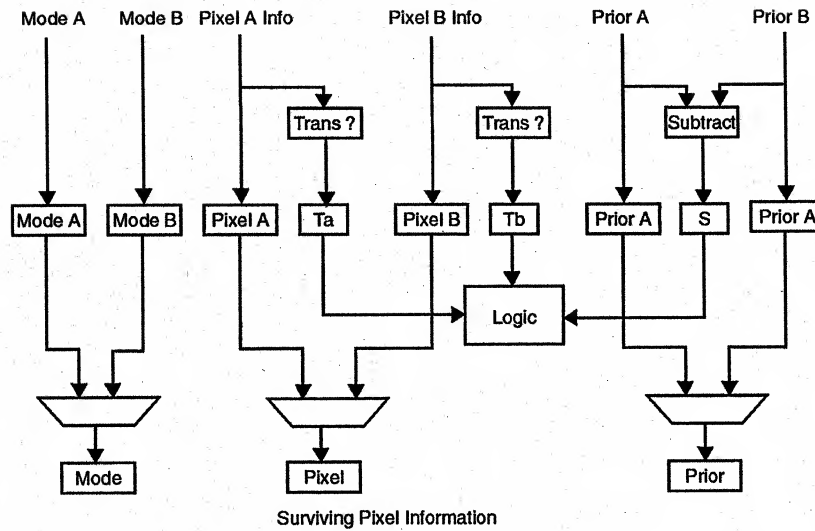
(610) 431-9298

hepler@commodore.com



Commodore Confidential

Pixel Prioritization



Dr. Edward L. Hepler

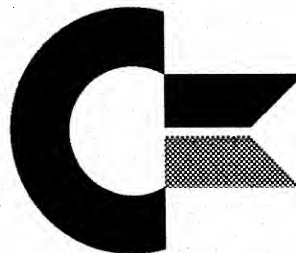
Commodore

1200 Wilson Drive

West Chester, Pennsylvania 19380

(610) 431-9298

hepler@commodore.com



Modified: April 12, 1994
Created: October 18, 1993

Playfield Scaling

- Playfields are independently scaleable both vertically and horizontally.
- The scaling ranges from 1/2 to 16x in increments of 1/16
- The entire playfield image is loaded into the line buffer each line
- Fractional scaling is achieved by either skipping or repeating the n-th pixel or line as it is being read from the line buffer.

Scale factor:

x-scale 0x1.0 (1)

y-scale 0x1.0 (1)

1	2	3	4	5	6	7	8
9	A	B	C	D	E	F	0
8	7	6	5	4	3	2	1
0	F	E	D	C	B	A	9

Scale factor:

x-scale 0x1.8 (1-1/4)

y-scale 0x1.4 (1-1/2)

1	2	3	4	4	5	6	7	8	8
9	A	B	C	C	D	E	F	0	0
9	A	B	C	C	D	E	F	0	0
8	7	6	5	5	4	3	2	1	1
0	F	E	D	D	C	B	A	9	9
0	F	E	D	D	C	B	A	9	9

Scale factor:

x-scale 0x0.8 (1/2)

y-scale 0x0.8 (1/2)

1	3	5	7
8	6	4	2

Scale factor:

x-scale 0x2.2 (2-1/8)

y-scale 0x0.C (3/4)

1	1	2	2	3	3	4	4	5	5	6	6	7	7	8	8	8
9	9	A	A	B	B	C	C	D	D	E	E	F	F	0	0	0
8	8	7	7	6	6	5	5	4	4	3	3	2	2	1	1	1

TMCD

Dr. Edward L. Hepler

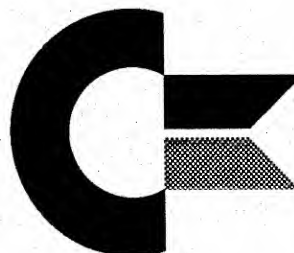
Commodore

1200 Wilson Drive

West Chester, Pennsylvania 19380

(610) 431-9298

hepler@commodore.com



Modified: April 12, 1994

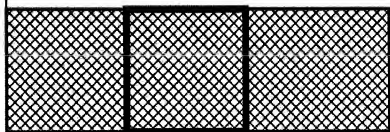
Created: October 18, 1993

Page 53 of 64

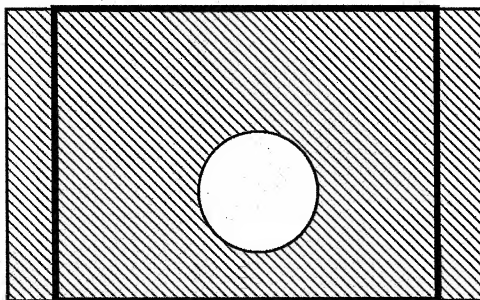
Commodore Confidential

Playfield Display Windows

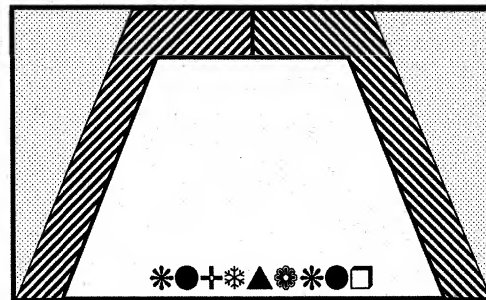
Playfield 0 memory Image



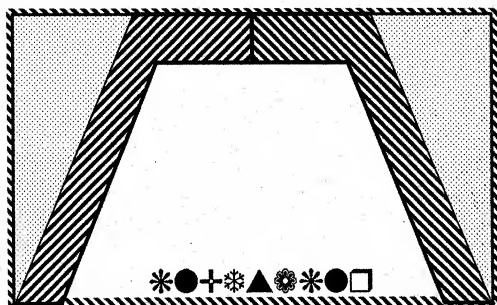
Playfield 2 memory image



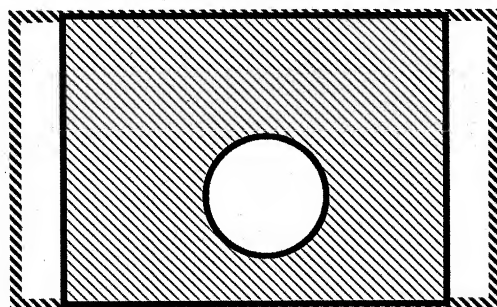
Playfield 3 memory image



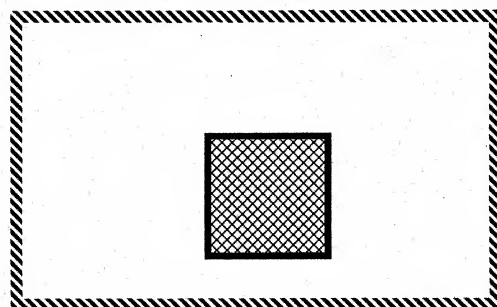
Display Window 3 (720x480)



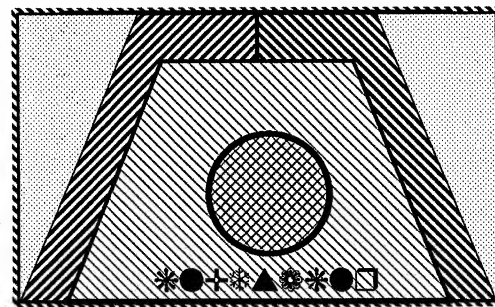
Display Window 2 (640x480)



Display Window 0 (200x200)



All Playfields may be independently sized, scaled, and positioned within the video frame.



For this example:

Display Window 3 is full screen

Display Window 2 is full height, but partial width

Display Window 0 is partial height and width

TMCD

Dr. Edward L. Hepler

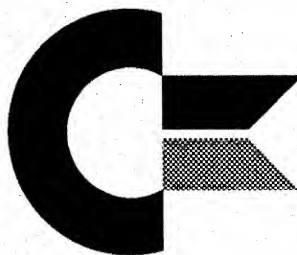
Commodore

1200 Wilson Drive

West Chester, Pennsylvania 19380

(610) 431-9298

hepler@commodore.com



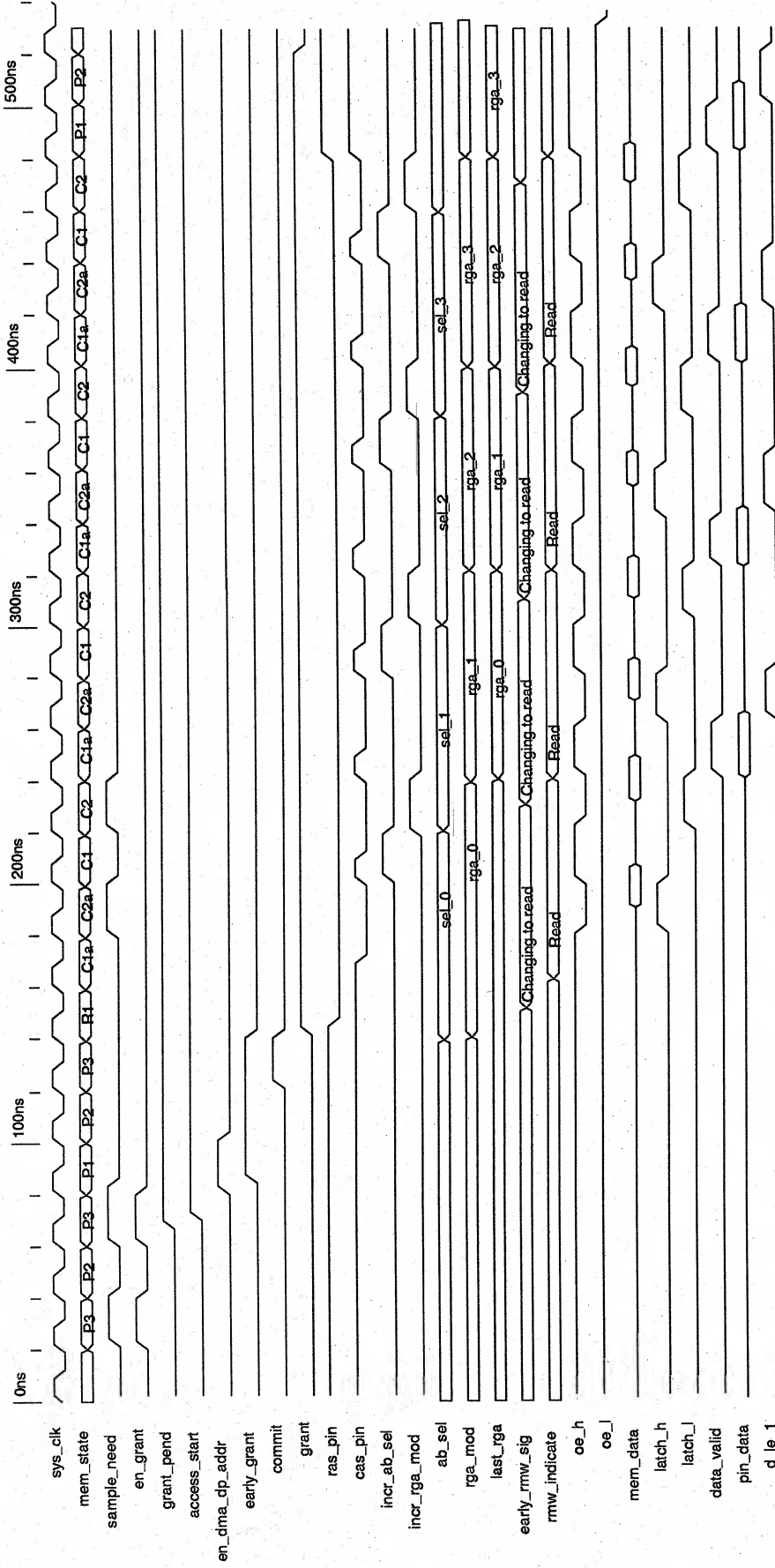
Modified: April 12, 1994

Created: October 18, 1993

Page 54 of 64

Commodore Confidential

32 bit Memory Read Access



**Read Non-Interleaved
32-bit Bus
64-bit Access
"read 32.td"**

Dr. Edward L. Hepler

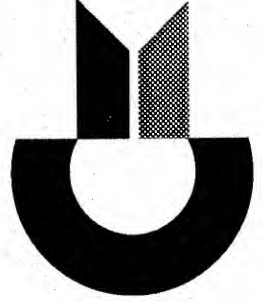
Commodore

1200 Wilson Drive

West Chester, Pennsylvania 19380

(610) 431-9298

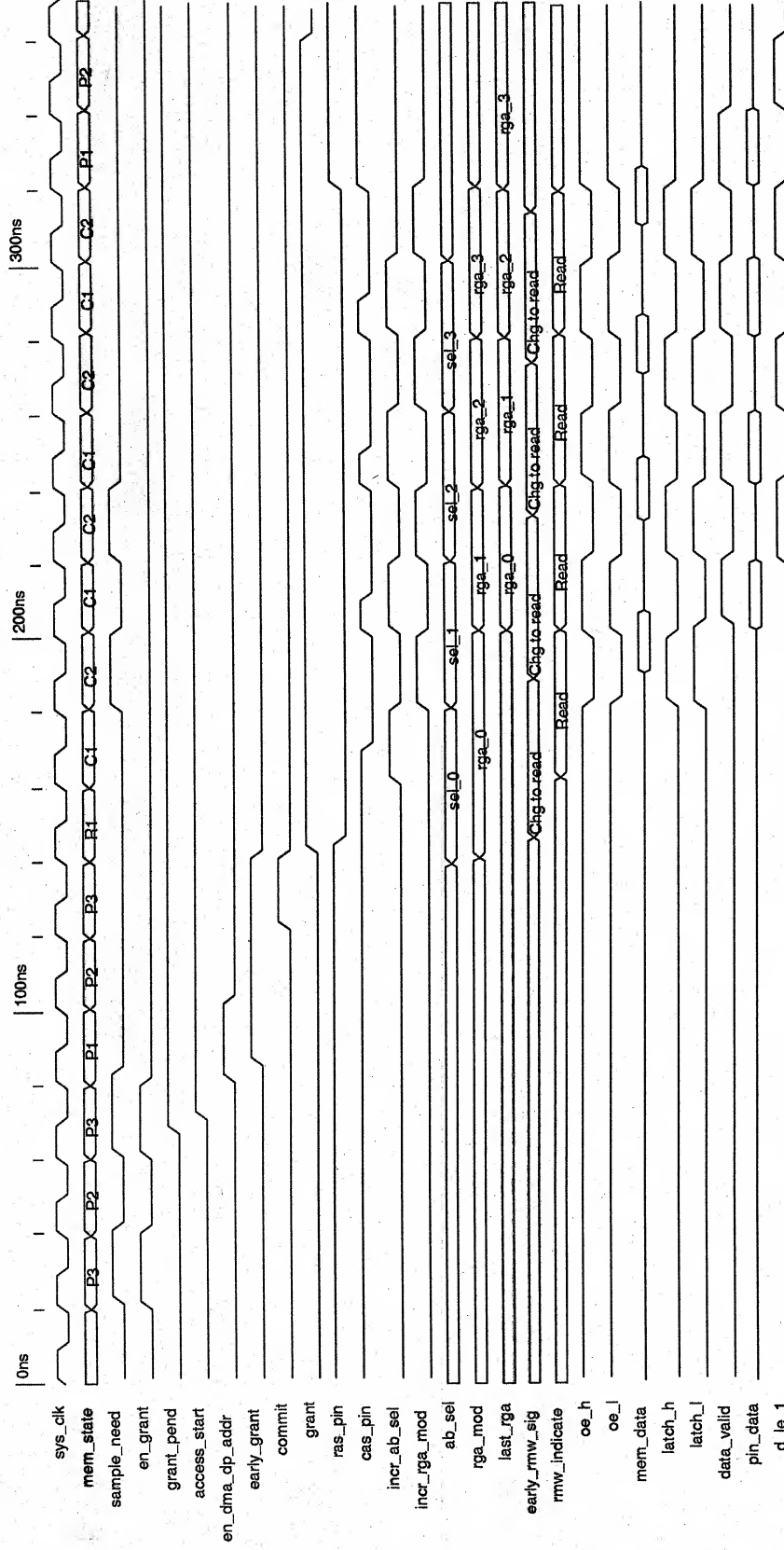
hepler@commodore.com



Commodore Confidential

Modified: April 12, 1994
Created: October 18, 1993

64-bit Memory Read Access



Read Non-Interleaved
64-bit Bus
64-bit Address
read_64bit

Dr. Edward L. Hepler

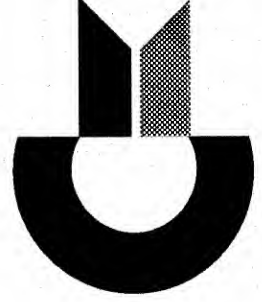
Commodore

1200 Wilson Drive

West Chester, Pennsylvania 19380

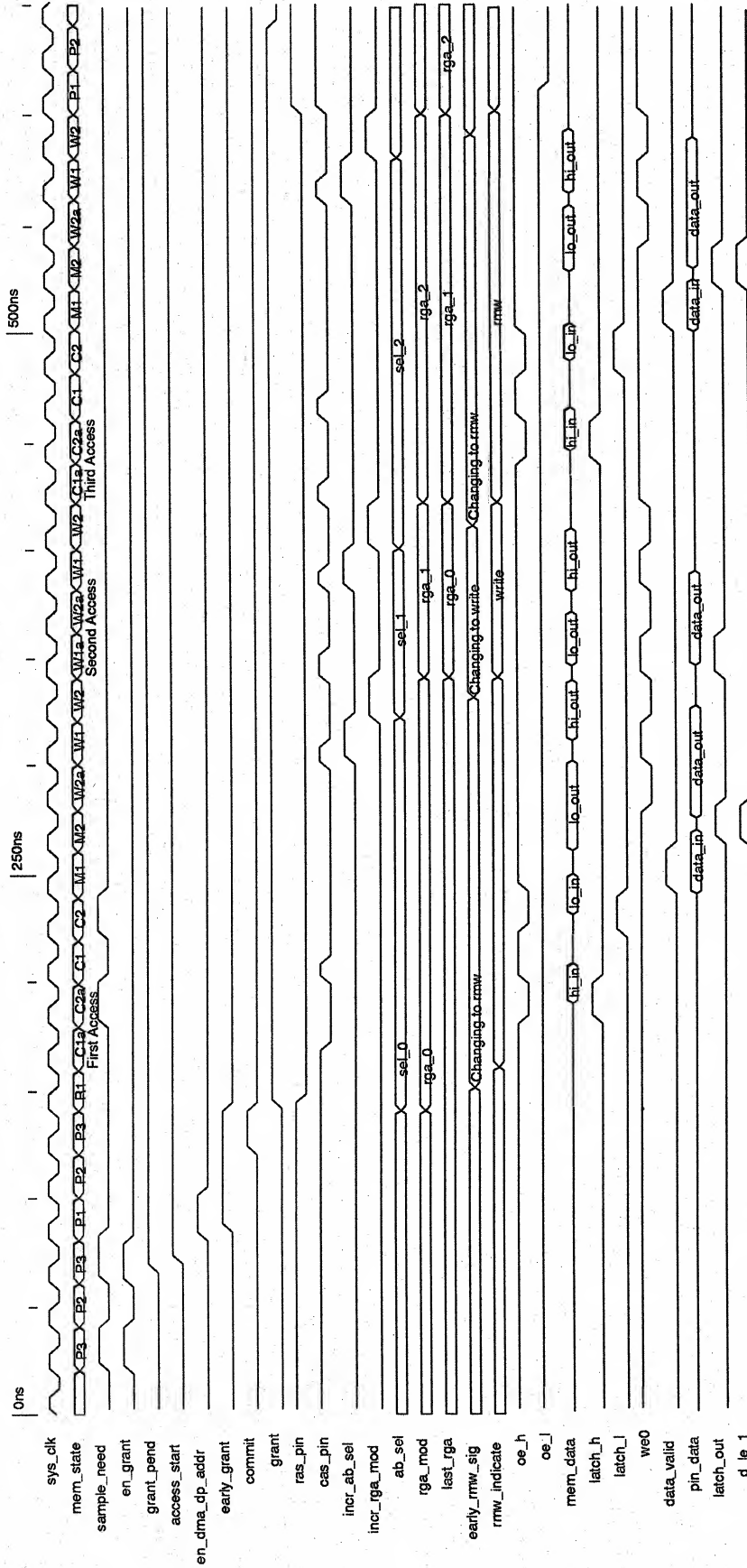
(610) 431-9298

hepler@commodore.com



Commodore Confidential

32-bit Memory RMW Access



Read-Modify-Write
Non-Interleaved
32-bit Bus
64-bit Access
rmw_32.td

Dr. Edward L. Hepler

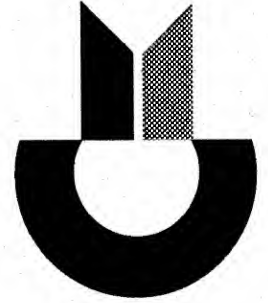
Commodore

1200 Wilson Drive

West Chester, Pennsylvania 19380

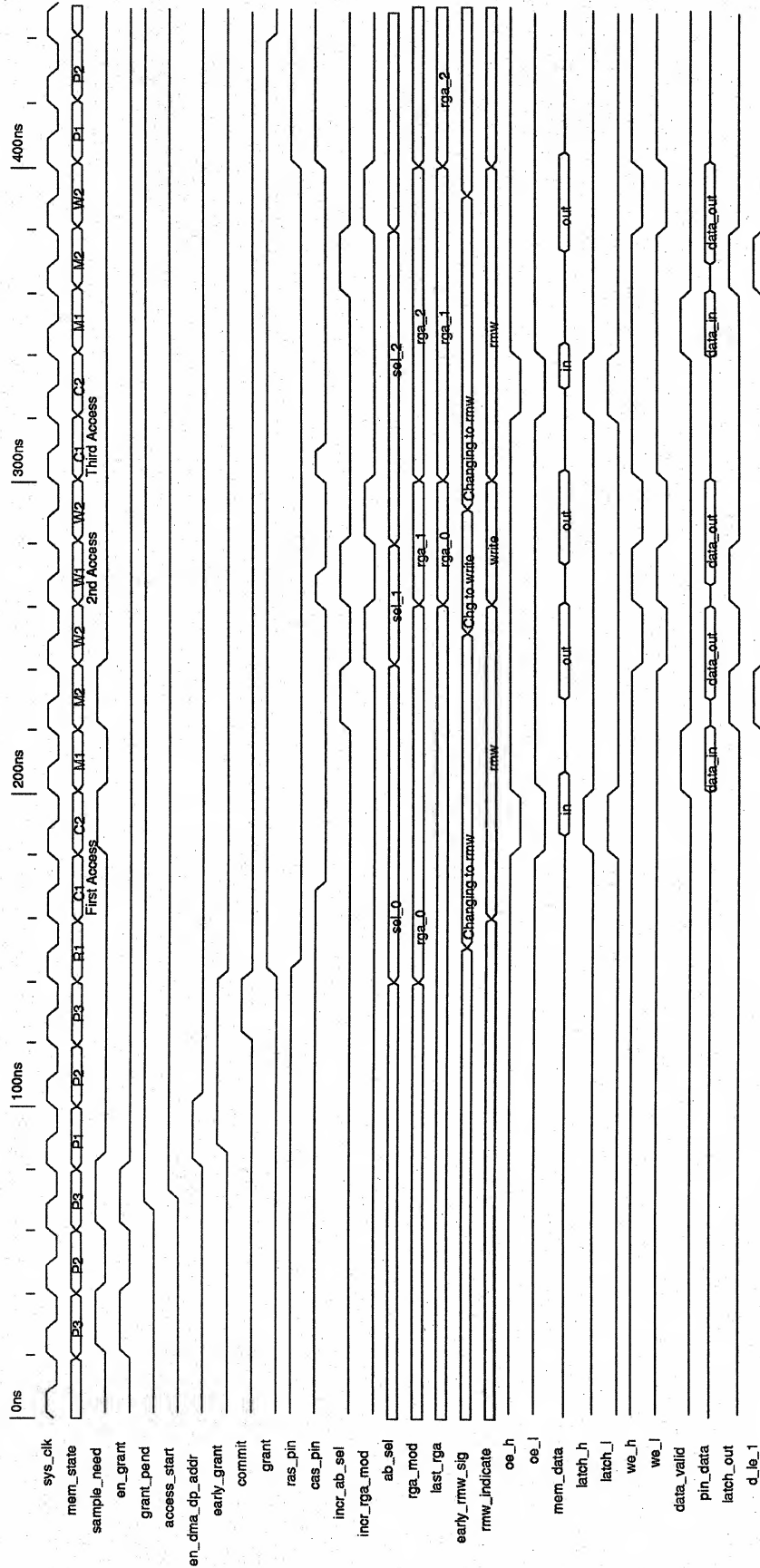
(610) 431-9298

hepler@commodore.com



Commodore Confidential

64-bit Memory RMW Access



Read-Modify-Write
Non-Interleaved
64-bit Bus
64-bit Access
rmw_64.td

Dr. Edward L. Hepler

Commodore

1200 Wilson Drive

West Chester, Pennsylvania 19380

(610) 431-9298

hepler@commodore.com



Commodore Confidential

Circuit Size Estimates

Dr. Edward L. Hepler

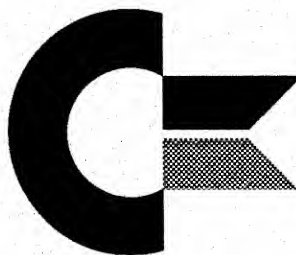
Commodore

1200 Wilson Drive

West Chester, Pennsylvania 19380

(610) 431-9298

hepler@commodore.com



Modified: April 12, 1994
Created: October 18, 1993

Page 59 of 64

Commodore Confidential

Design Methodology

- **0.6 micron - 3 level metal CMOS - 3.3 Volt process**
- **Structured custom design technique**
 - Datapaths (highly regular structures): full custom
 - Control logic: Synthesized via AutoLogic (M models)
- **Design Tools**
 - Schematic Capture: Design Architect (Mentor)
 - Simulation (Behavioral): Lsim (Mentor)
 - Simulation (Switch): Lsim (Mentor)
 - Simulation (Circuit): Hspice (MetaSoftware)
 - Synthesis: AutoLogic (Mentor)
 - Layout: Cadence
 - Place and Route (Standard Cells): AutoCells (Mentor)
 - Chip Assembly (Block place and route): SCII (Silver-Lisco)
 - Netlisting Tools: Commodore Proprietary

Dr. Edward L. Hepler

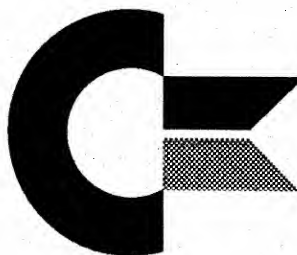
Commodore

1200 Wilson Drive

West Chester, Pennsylvania 19380

(610) 431-9298

hepler@commodore.com



Modified: April 12, 1994
Created: October 18, 1993

Page 60 of 64

Commodore Confidential

Status...

- **Schematics for many major blocks have been captured**
- **M language, synthesizable, behavioral models have been written for much of the functionality of the chip set.**
- **Some simulation has been started, much remains to be done.**

Dr. Edward L. Hepler

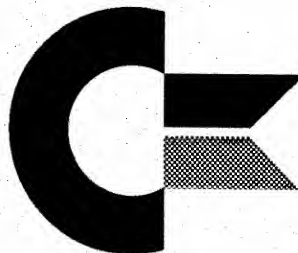
Commodore

1200 Wilson Drive

West Chester, Pennsylvania 19380

(610) 431-9298

hepler@commodore.com



Modified: April 12, 1994
Created: October 18, 1993

Page 61 of 64

Commodore Confidential

Future?

- **Rambus? version**
- **Single Chip version**

Dr. Edward L. Hepler

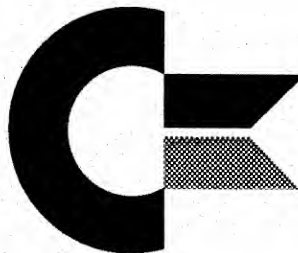
Commodore

1200 Wilson Drive

West Chester, Pennsylvania 19380

(610) 431-9298

hepler@commodore.com



Modified: April 12, 1994
Created: October 18, 1993

Page 62 of 64

Commodore Confidential

What do WE want?

- **License to produce an implementation of PA-RISC**
- **Architecture validation suite**
 - Instruction test sequences
 - Emulators
- **Software generation tools**
 - C and C++ Compilers
 - Assembler - we need to modify for our enhancements
 - Other tools...
- **IEEE Floating Point Emulation Code**
 - Study to determine if SFU instructions may be appropriate
- **Access to higher end Operating Systems**
 - UNIX
 - Windows/NT
- **Link to higher end product line**

Dr. Edward L. Hepler

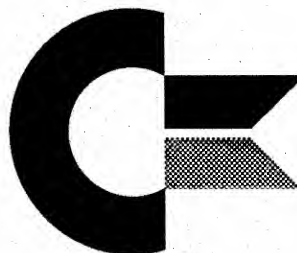
Commodore

1200 Wilson Drive

West Chester, Pennsylvania 19380

(610) 431-9298

hepler@commodore.com

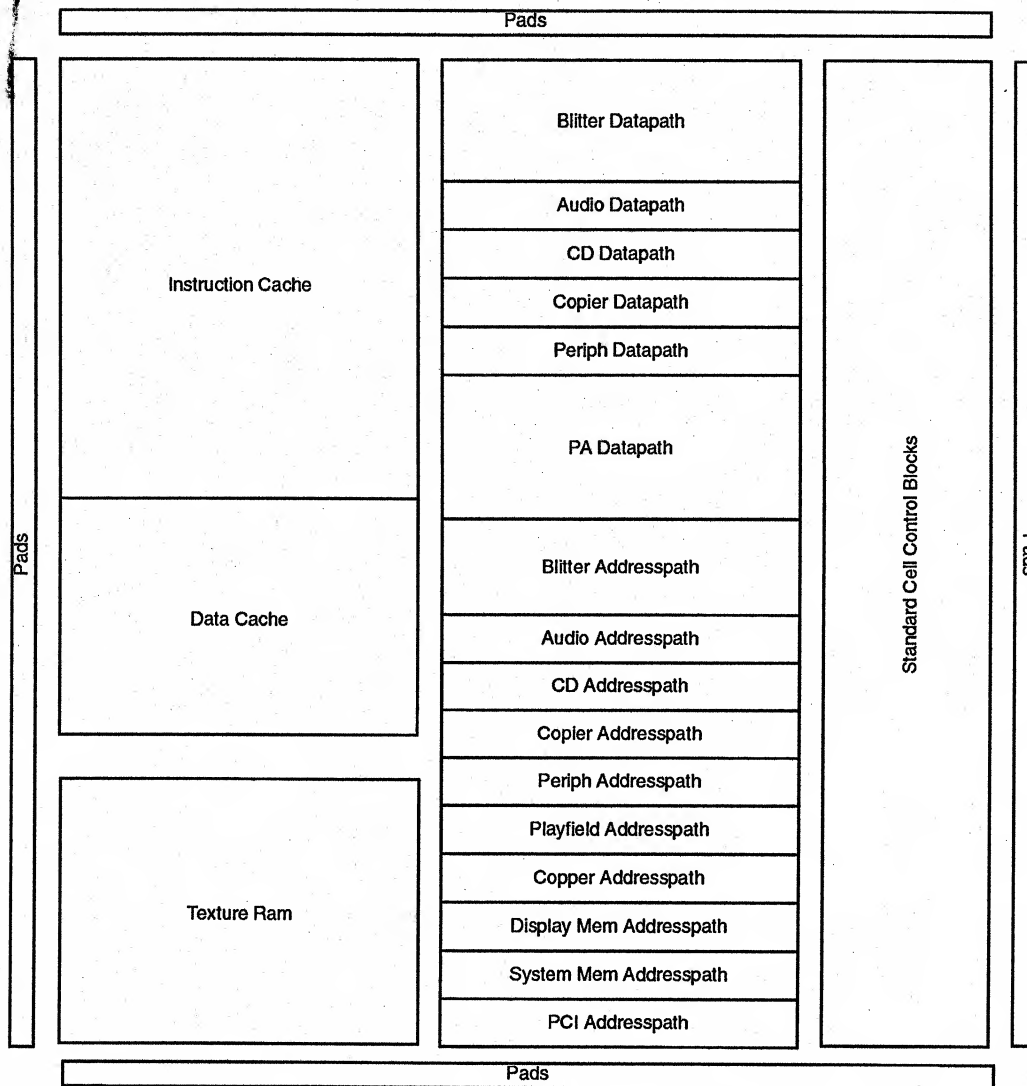


Modified: April 12, 1994
Created: October 18, 1993

Page 63 of 64

Commodore Confidential

CPU Floorplan (First Cut)



- 0.6u Three-Layer Metal, 3V CMOS
- Estimate 9 x 9mm to 10mm x 10mm Die Size

Dr. Edward L. Hepler

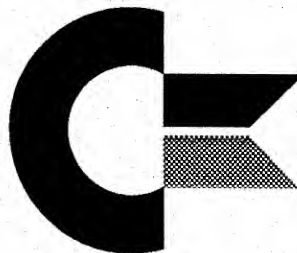
Commodore

1200 Wilson Drive

West Chester, Pennsylvania 19380

(610) 431-9298

hepler@commodore.com



Modified: April 12, 1994
Created: October 18, 1993

Page 64 of 64

Commodore Confidential